COMPARATIVE STUDY OF RESISTIVITY SURVEY AND DOWSING METHOD TO LOCATE GROUNDWATER POTENTIAL ZONES

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***Abstract*—The following report is a comparative study of the resistivity survey method and dowsing method for detection of ground water potential zones. The survey was carried out on a 20 x 20 sq.m. block in the sports ground of Pad. Dr.D.Y.Patil Educational Complex, Akurdi, Pune .The survey was executed in two phase's viz. Pre-monsoon & Post-monsoon to study the seasonal variation in ground water flow. Initially the resistivity survey was carried out which was followed by the dowsing method. The potential ground water zones have been demarcated along with the comparison of results from both afore mentioned methods. The resistivity variations with season are also noteworthy from post-monsoon to pre-monsoon**

I. INTRODUCTION

Groundwater is abstracted from beneath the earth's surface using methods similar to the oil industry .Wells are drilled into aquifers and pumps are used to bring groundwater to the surface. In some cases groundwater may naturally flow out of a well, which is known as artesian flow.

The existence of artesian flow is not necessarily an indication of high well or aquifer yield. It is a physical phenomenon reflecting aquifer conditions where by groundwater is trapped below an impermeable layer, in conjunction with recharge at a higher level. As groundwater resources approach full allocation across the region, there is an increasing call for information on regulatory matters, reflecting competing demand between water users.

II. RESOURCE INFORMATION

A. Geology and geomorphology

The subsurface mapping of geological formations and the location of old stream channels can help build a picture of how an area has been formed and where groundwater may be found. This is a systematic and scientific way of learning about the potential groundwater resources of an area , that is a relatively cost effective first step. Despite the fact that today there are various methods available for predicting the nature of sub-surface formations, there is still only one sure way of finding out and that is drilling.

B. Water divining

Drilling a hole in the ground can be an expensive business, particularly if water is not found the first time. A traditional means of groundwater exploration is called water divining or dowsing. The mystique of water divining or dowsing still has a hold on the popular mind today and is regularly used by some drilling contractor sand many well owners. Water divining is not universally accepted as a proven method of locating groundwater. While there have been some notable successes locally, there have also been some costly failures. Water divining is either something you believe in or not, and it's effectiveness is very much in the eye of the beholder .Diviners have on several occasions been tested scientifically and some researchers have gone as fares to conclude that diviners have at best about a 10 to12% chance of success. It seems more than likely that diviner shave a value in areas they know. They can compute in their mind the many factors they have assimilated such astopography, history and geology; and make a good prediction at the best location for a well. Divining gives people confidence to proceed which they may not otherwise have had, particularly if all other approaches have been exhausted. Whether this is false or otherwise will be argued far into the future.

C. Geophysical exploration

Well drilling is the only direct way of exploring for subsurface groundwater systems, but it is very expensive. Enough bores have to be drilled to sufficient depth to describe the depth, extent and constituency of the various geological formations. Indirect methods such as geophysical prospecting are still expensive, but provide the benefit of covering large areas. Geophysical techniques identify anomalies or differences in the earth's properties such as changes in rock type, the degree

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of saturation or its chemical composition. Through experience these results have been interpreted to tell us about subsurface conditions. Of particular interest is the existence or absence of groundwater, its quality and depth. Geophysical methods only give an indication of what is below the ground because they are indirect methods. Less reliance is placed on the results, but they are useful for defining parameters such as the depth to basement or the likely location of aquifers for example, where less precision is acceptable. Geophysical methods were originally developed for oil and mineral exploration, but as water has become scarcer and more valuable, they have been adapted and applied to groundwater exploration. However, it is an inexact science, and the results are often difficult to interpret. While it hasn’t always been successful, overall it has improved understanding of groundwater resources and particularly subsurface sedimentary structures.

D. Electrical resistivity

To date the most commonly used prospecting method has been the electric resistivity technique. It is especially useful in targeting the most likely drilling sites in marginal areas, and in some but not all cases, this has paid off locally. This method is a reasonably cost effective way of obtaining a broad coverage of sub-surface formations. It involves inducing a known electrical current into the ground via two electrodes, and evaluating the resistivity of the ground material based on the measured potential difference in two other electrodes Electric resistivity is a relatively cheap method and suited to the gravel type aquifers meters represents the upper three to six meter thick band of highly permeable recent river gravels.

E. Seismic

Seismic surveys are another geophysical method used locally, which can penetrate to greater depths below the earths surface than the electric resistivity technique. This method has been used to identify regional scale geological differences such as the depth to basement and boundaries between sedimentary materials. The seismic method works on the principle that sound waves travel at different speeds depending on the density of a rock and its water content. Hard, crystalline rocks transmit sound waves at speeds of up to 5,000 meters per second compared to only several hundreds of meters per second for an unconsolidated sand or alluvial gravel. The method works by measuring the two way travel time for sound or seismic waves generated at the surface to travel through the earth’s crust at very high speed. Because these waves travel at different velocities through rocks or sediments of different types, differences in subsurface material can be interpreted. It does however only work well if there are contrasts in the densities of the material encountered. Survey location map the method for example, may not differentiate between granite and schist or between two sedimentary gravel formations because they are too similar in composition. It may also be unsuccessful if the basement rock is highly weathered, and a sharp boundary doesn’t exist with the overlying alluvium. The seismic reflection method measures the two way travel time of sound waves generated at the surface.

Returning waves can travel a number of different routes. They can take a direct line, or be reflected or refracted; depending on the earth’s composition locally. Receivers called geophones are laid out in a specific pattern at the surface. These record the time that sound waves arrive at varying distances from the source. The depth of penetration is limited to the layer with the highest sound velocity as this layer will tend to deflect all waves from travelling deeper. The depth to a boundary between two rock types is determined by the difference in arrival times of the first shock waves at each geophone. The first arrivals will represent waves travelling the short distance through the shallow sand formation. Deeper waves that are reflected back after travelling faster through the denser, deeper material will start to arrive first in the more distant geophones. As with all geophysical techniques the seismic method is an approximation of the real world, and there is normally no unique answer for any set of results. Computers are used to analyze the large amount of information collected during a typical survey and create a model of what may exist in reality. Seismic surveys are commonly used overseas for identifying regional scale structures such as salt domes or anticlines that naturally trap gas or oil, and lie up to several kilometers underground.

F. Isotope method

This method is mainly useful for tracing the water flow and to estimate the age of the groundwater. We know that the phreatic layer is renewed by the infiltration of water through the inflow area, where the aquifer’s geological structure is exposed to the surface. Investigations using the isotope method can often give useful indications. If there are infiltrations, they can be detected and assessed by analyzing the variations in the isotope content of the damp soil above the phreatic layer. The most used isotopes are tritium, deuterium, oxygen 18 and carbon 14. The results have shown that this method is reliable and promising, in particular if it is used with the physical models describing the water flow.

G. Proton magnetic resonance

It is also known as the Nuclear Magnetic Resonance (NMR), is a property of hydrogen protons which produce a magnetic field when they are excited by an alternative field in the presence of a static magnetic field. Most hydrogen atoms located in the ground are coming from water molecules. The direct detection of water can thus be envisioned with such a method, while conventional geophysical methods only provide structural information.

In the PMR method, three magnetic fields have to be considered:

1. The Earth's field, the amplitude of which determines the precession frequency of the protons.
2. The excitation field, produced by a current into a loop laid on the surface of the ground, at a frequency equal to the precession frequency (called the Larimore frequency).
3. The relaxation field produced by the protons excited by the previous field. The amplitude of the relaxation field measured at the surface, after the excitation current is turned off, is

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directly linked to the number of protons which have been excited and thus to the water content.

III. ELECTRICAL RESISTIVITY METHOD

3.1 Principle

• Groundwater contains various dissolved salts and it is ironically conductive, this enables electric currents to flow into ground. As a result, by calculating the ground resistivity it gives the possibility to the availability of water, taking in consideration the following properties:

• A hard rock with no pores or fracture and dry sand devoid of the water or clay are extremely resistive: several tens thousands ohm-m.

• A porous or fractured rock containing free water has a resistivity that depends on resistivity of the water and on the porosity of rock, several tens to several thousand ohm-m

• An impermeable clay layer, containing bound water, has low resistivity: several units to several tens ohm-m

• Mineral ore bodies such as iron, sulphide etc have very low resistivity because of their electric conduction: usually less or much less than 1 ohm-m.

Know your Instrument

The main instrument is opened with a lid hinged out at the left side .We can observe following controls.

3.2 Measuring Principle:-

In the arrangement for the measurement of resistivity, the four electrodes are driven in to the ground at equal distance. When the current is passed through the outer electrodes, a potential difference is set up between the inner pair. This potential is measured on the meter. Then it is compared with the potential drops across a known resistance. The value of resistance giving the same potential drop is the apparent resistance between the inner electrodes.

AQUA I And AQUA II PULS Resistivity Meter:-

Aqua II (figure no. 7) is a compact, self contained instrument based on the principle of electrical resistivity. It consists of two units housed in metal cases. One unit-The Generator-generates the necessary low frequency square wave current. The second unit- The Amplifier-contains the necessary circuit to measure the resistivity of the ground. For precise measurement, low frequency square wave current is applied between two electrodes driven in to ground and potential difference between two other electrodes in the measurement zone is measured. A set of readings is obtained to determine the average electrical resistivity of the section.

Figure 1:- AQUA II PULS Instrument

Generator:-

The generator generate low frequency (4Hz) square wave. The unique feature of this generator is that, it uses a specially designed electronic circuit to reduce the weight. The generator supplies perfect square wave 4Hz output in two stage namely 100V & 200V. The final communication is achieved using a D.C.relay.

Specification:-

Power Supply – 12 X 1.5(V) type Eveready 1055 or equivalent dry cell. For Aqua II or 12(V) external lead acid battery for Aqua II Plus with charger box.

Power Output-about 4(W) for Aqua II and 40 (W) for Aqua II Plus.

Output Voltage-two ranges 100 & 200(V), 4(Hz) approx for Aqua II & 200 & 400(V), 4(Hz) approx for Aqua II Plus .

Dimesion-360 X 135 X 170 mm approx

Weight- 3(kg) approx

Amplifier:-

This unit consists of a filter and an amplifier. The filter is used to filter out unwanted signals and to allow only the signal generator by the generator to pass through. Thus the effects of DC ground current and 50Hz power lines are eliminated and the selected signal passed on to the cells. Integrated circuit is used for high stability.

The Amplifier is provided with minimum controls, which enable in getting quick readings. The external, internal switch is used to record the potential developed between the points P1 P2 and to compare it by using the ten turn helical potentiometer. Depending upon the position of the range selector, the reading of the potentiometer is recorded by using appropriate multiplying factor. Coarse gain and Fine gain control are used to get a reading of 5 to 45 divisions on the meter on 'external' settings. To assess the battery condition on the meter a push button is provided.

3.3 Specification:-

Power supply- 2 X 9V cells Eveready type 6F22

Ranges- 0-1 ohm
0-10 ohm
0-100 ohm
0-1000 ohm
0-10000 ohm

For Aqua II and additional 0-0.1ohm range for Aqua II plus.

Weight- 3kg approx or 4.5kg with 12 x 1.5V dry cells.

Dimension- 360 X 135 X 170 mm approx

Accuracy- ±5% up to 0.01ohm, ±10% up to 0.003 ohm

Salient Feature

1) The instrument incorporates all indigenous components which insure accurate results in any type of weather.

2) The controls and indicators are conveniently placed to achieve ease and speed of operation.

3) The very low frequency square wave alternating current generated by generator avoids electrode polarization and reduces capacitive effects to a minimum value.

4) The use of two separate units reduces flux linkage between the generator and the amplifier circuits. Integrated circuits and

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effective filter make the amplifier highly intensive towards power line or cable and telluric current interference.

5) The accuracy of measurement is within ±5% from 0.01ohm to 10000ohms and ±10% below 0.01ohm.

6) Depth of penetration is 600m at ρ =50 ohm-m for Aqua II and 600m at ρ=10 ohm-m for Aqua II Plus.

General:-

1) The generator box and The Amplifier box are interconnected by a two cable conductors between the reference terminals on both the instrument panels. No observation of polarity is needed. The cables from the current electrodes are connected to the terminals C1 and C2 and cable from potential electrodes to P1 and P2.

2) Do not touch the current electrodes when the current is flowing. The operator must insure that the generator is switched off before moving the electrodes and switched on after fixing the electrodes.

3) Switch off the generator unit after adjusting the ten turn helical potentiometer to minimize the battery drain.

4) Observe the ticking sound of the relay at four cycles in the generator until when it is switched on.

3.4 Principle :-

1. Marking Grid on Ground of required dimensions.
2. Fixing props at required point.
3. Taking Readings.

IV. GEO-PHYSICAL INVESTIGATION BY ELECTRICAL RESISTIVITY METHOD:-

Sample Observation:-

1. Post Monsoon

POINT	DEPTH	RESISTANCE	RESISTYVITY
D	3	1.32	24.9
	6	0.937	35.3
	9	0.897	50.7
	12	0.653	49.2
	15	0.716	67.4
	18	0.682	77.1

2. Pre- Monsoon Reading

POINT	DEPTH	RESISTANCE	RESISTIVITY
D	3	2.07	39.0
	6	1.69	63.7
	9	1.39	78.6
	12	1.26	95.0
	15	0.951	89.6
	18	0.894	101.1

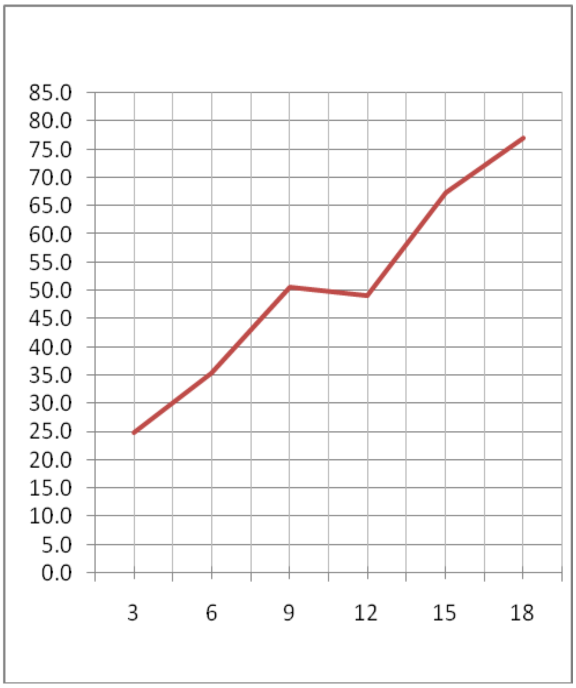

Fig no 2.Post monsoon graph of resistivity (on y axis) Vs depth on (x axis)for point D.

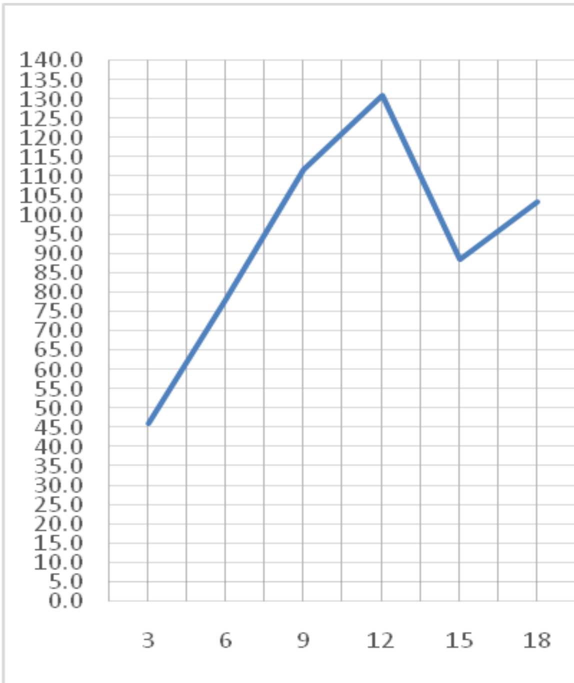

Fig no .3.Premonsoon graph of resistivity (on y axis) Vs depth on (x axis)for point .D

ISSN: 2278 – 7798

RESULTS:

The graph of Depth V/s Resistivity is plotted for all 25 points on the grid. The following points were observed regarding the variations present in groundwater resistivity with respect to depth.

A	G	F	E	D
H	I	J	K	L
Q	P	O	N	M
R	S	T	U	V
B	W	X	Y	C

***For Post Monsoon*:-**

- Point D:-Drop in resistivity, with respect to depth is observed between 9m. to 12m from 50.7 ohm-m to 49.2 ohm-m.
- Point A:-Drop in resistivity, with respect to depth is observed between 9m to 12m and 15m.to 18m. From 74 ohm-m to 55.8 ohm-m. And 119.6 ohm-m to 56.5ohm-m respectively.
- Point C:-Drop in resistivity, with respect to depth is observed between 12m to 15m from 45.2 ohm-m to 3.8 ohm-m.

A) For Pre-Monsoon:-

- Point D:-Drop in resistivity, with respect to depth is observed between 12m to 15m from 95 ohm-m to 88.6 ohm-m.
- Point E:-Drop in resistivity, with respect to depth is observed between 12m to 15m from 131.1 ohm-m to 88.6 ohm-m
- Point F:-Drop in resistivity, with respect to depth is observed between 12m to 15m from 150 ohm-m to 92 ohm-m
- Point G:-Drop in resistivity, with respect to depth is observed between 12m to 15m from189.3 ohm-m to 108.7 ohm-m
- Point I:-Drop in resistivity, with respect to depth is observed between 12m to 15m from 196.9 ohm-m to 112.5 ohm-m
- Point J:-Drop in resistivity, with respect to depth is observed between 12m to 15m from 155.2 ohm-m to 94.1 ohm-m
- Point K:-Drop in resistivity, with respect to depth is observed between 12m to 15m from 139.4 ohm-m to 91.2 ohm-m
- Point L:-Drop in resistivity, with respect to depth is observed between 12m to 15m from 110.8 ohm-m to 290.8 ohm-m
- Point M:-Drop in resistivity, with respect to depth is observed between 12m to 15m from 128.5 ohm-m to 94 ohm-m
- Point N:-Drop in resistivity, with respect to depth is observed between 12m to 15m from 143.2 ohm-m to 94.2 ohm-m
- Point O:-Drop in resistivity, with respect to depth is observed between 12m to 15m from 160.5 ohm-m to 96.1 ohm-m
- Point P:-Drop in resistivity, with respect to depth is observed between 15m to 18m from 202.5 ohm-m to 117.6 ohm-m

CONCLUSION:

Thus from the above observations it can be inferred that there is a ground water potential zone between the depths 12m. to 15m. in the region OEFJONM and extending to FGIPO for a depth between 15 m. to 18 m as shown in fig. 5.

Comparing the observations from the Dowsing Method and Electrical resistivity method, the following conclusions can be drawn:

For Post-Monsoon observations:-

- According to the graphs of depth v/s resistivity, the points. The points A, B, C, D, Y. shows the potential groundwater zones at 12m. and below . Also the vein diagram made by dowsing methods showed veins flowing through the above mentioned points.

For Post-Monsoon observations:-

- According to the graphs of depth v/s resistivity, the points. The points A, D, E, F, G, I, J, K, L, M, N. O, P, Y shows the potential groundwater zones at 12m. And below. Also the vein diagram made by dowsing methods showed veins flowing through the above mentioned points.

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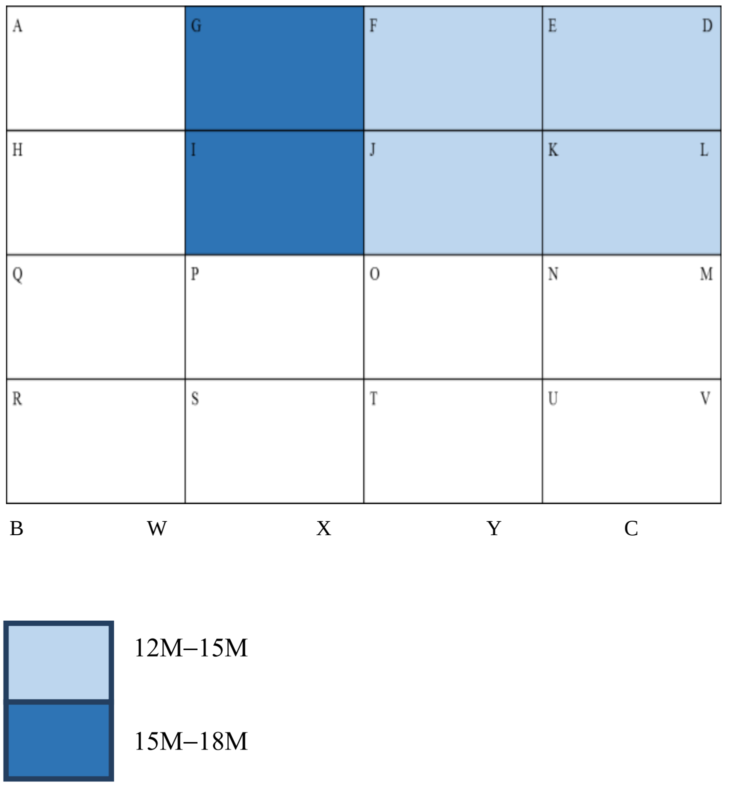

Fig no 5.Demarcation of ground water potential zone in grid as per conclusion.

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